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TITLE COMPARISON OF EIGENVALUE COMPUTATIONS FOR THE SAVANNAH RIVER K REACTOR USING 2 AND 8 DIGIT DIMENSIONAL AND ISOTOPIC QUANTITIES

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COMPARISON OF EIGENVALUE COMPUTATIONS FOR THE SAVANNAH RIVER K REACTOR USING 5 AND 7 DIGIT DIMENSIONAL AND ISOTOPIC QUANTITIES

BY

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A study was undertaken to characterize the reactivity temperature coefficient (RTC) behavior for the Savannah River K-Reactor pursuant to the safety review mandated by the Department of Energy (DOE) in August 1988. During the course of the investigation, it was found that the accuracy levels required in dimensional and isotopic quantities at elevated temperatures were much greater than was initially supposed and are typically used in reactor neutronics calculations. The codes involved do not automatically calculate dimensional and density changes due to temperature. This paper discusses and compares calculated eigenvalues obtained from using 5, 6, and 7 digit dimensional and isotopic densities used in the Mark 22 fuel assembly[1] cell models.

The ONEDANT[2] S_n transport code and the GLASS[3] and WIMS-D[4] collision probability transport codes were used to obtain eigenvalues of infinite lattice cell configurations. WIMS-D and GLASS have associated cross section sets that are self shielded and temperature dependent. The ENDF/B-V MATXS7[5] 69-group library was used with the code TRANSX[5] to provide self shielded temperature dependent cross sections for ONEDANT.

The cell model was a single Mark 22 fuel assembly surrounded by D_2O moderator. The Mark 22 fuel assembly consists of a central low-flow rate D_2O inner dead space region, surrounding annuli of ^{6}Li-Al target regions and ^{235}U fuel regions sandwiched between high flow

rate D_2O coolant regions, an outer low-flow rate D_2O region (outer dead space) , and an outside housing.

The calculations proceeded from a base case isothermal calculation at 296 K. Calculations at elevated temperatures were made after expanding the radii and changing the density and cross sections to correspond to a new temperature for a specific region, for example the fuel. Isothermal temperature profiles were perturbed on a region-by-region basis to obtain data and corresponding calculated eigenvalues for the temperature range 296 to 400 K at ten degree intervals. The expansion was in three dimensions. The calculations typically employed about 100 space points, a convergence criterion of 10^{-6} or greater.

Five digit data (format 1.2345) for the material densities and radii were initially used in the analysis. Therefore, following an expansion due to a temperature change, material was conserved to five places and the expanded radii were rounded to five significant digits. The calculated metallic region temperature coefficients obtained using five digit data exhibit erratic behavior, manifested by fluctuations in value and in sign in a seemingly random manner when either the fuel or target temperature was perturbed by as little as 10 K.

A resolution to the conflicting results was discovered when it was found that seven-place accuracy in densities and radii was necessary to obtain consistent results. Table 1 gives the 5, 6, or 7 digit results for the three codes from 330 K to 400 K for the target. Code construction limits GLASS input to 6 digits. Figure 1 is a plot of k verses temperature for the target region from ONEDANT calculations. Note the erratic behavior in Figure 1 when 5 digit radii and atom densities are used. From the target reactivity profile it is apparent that positive or negative temperature coefficients can be calculated depending upon which values of k(T) are used.

It may be noted in Table 1 and Figure 1 that the eigenvalue is a well behaved function of temperature when seven digits are used.

The fuel assembly contains highly enriched uranium and ^{6}Li, both of which have large thermal absorption cross sections thus seven digits are required for consistency in the calculations. Similar behavior was noted for the fuel regions. These results demonstrate the need for extreme care when preforming analysis of this type.

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TABLE 1. Eigenvalues for the Mark 22 5-, 6-, and 7-digit calculations for changes in target temperature.

	ONEDANT		GLASS		WIMS-D	
Temp.(K)	$k_{eff:5-digit}$	$k_{eff:7-digit}$	$k_{eff:5-digit}$	$k_{eff:6-digit}$	$k_{eff:5-digit}$	$k_{eff:7-digit}$
330	1.088422	1.088263	1.08898	1.08895	1.086907	1.086735
340	1.088086	1.088243	1.08903	1.08892	1.086564	1.086715
350	1.088507	1.088222	1.08905	1.08893	1.086993	1.086694
360	1.088085	1.088201	1.08911	1.08890	1.086604	1.086673
370	1.088138	1.088176	1.08913	1.08888	1.086620	1.086648
380	1.088201	1.088155	1.08920	1.08890	1.086682	1.086627
400	1.088239	1.088110	1.08921	1.08886	1.086723	1.086582
450	-	1.088003	1.08902	1.08889	-	-

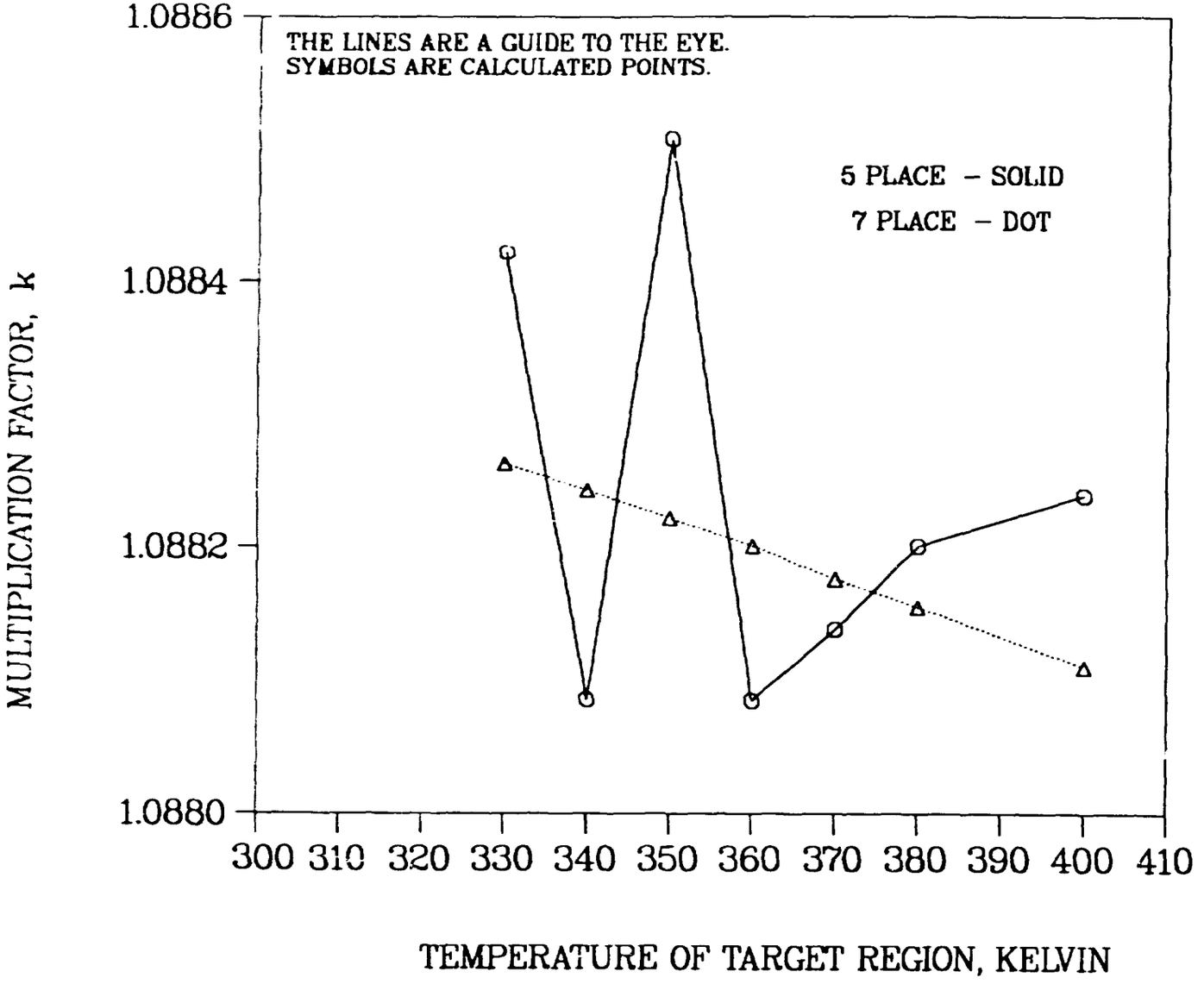

Fig. 1. NEUTRON MULTIPLICATION FACTOR AS A FUNCTION OF TARGET TEMPERATURE